Pastoralism: Research, Policy and Practice

RESEARCH Open Access

Camel milk production and marketing: Pastoral areas of Afar, Ethiopia

Belets Gebremichael[1*], Shishay Girmay[2] and Mu'uz Gebru[3]

Abstract

Dromedary camels produce more milk for a longer period of time than any other milk animal held under the same harsh conditions. Produced milk is a primary source of some pastoralists' food, nutrition and income security all year round. However, there are limited research efforts on exploiting camel milk potential and its promotion for consumption and marketing. Thus, a cross-sectional survey was conducted on 100 camel herders; nine traders and three cooperatives during March to April 2017 in Afar region of Ethiopia. Besides, discussions were held with district leaders, end consumers and local elders. Collected data were analysed using descriptive statistical tools, figures and diagrams. The survey result revealed that 56.6% camel herds were lactating. Milking was done by men twice (67%) and three times (33%) per day with an average of 4.2 L per camel. A total of 82% of the camel herders were marketers, and women were dominant. Camel herders sold an average of 14.3 L milk per day at an average price of USD 0.95 per litre, whereas middlemen sold an average of 35.8 L at USD 1.22 per litre. The milk trade was done at herders' farm gate (18.3%), main road-sides (58.5%) and nearest towns (23.2%) using small plastic pots (68.3%) and plastic jerrycans (31.7%). Amongst the three marketing channels, 69.9% of the milk was directly sold to end consumers and fetched a higher price than other marketing channels, but the routes are limited to local markets. The camel herders perceived that they satisfied with milk for its nutritional, medicinal, social and economic values. Therefore, interventions need to focus on exploiting opportunities, addressing challenges/constraints in camel milk production and its marketing chain efficiency and effectiveness.

Keywords: Afar, Camel herders, Camel milk, Dromedary camel

Introduction

More than 80% of the camel population inhabits Africa with 60% in the eastern African countries (Sudan, Somalia, Ethiopia and Kenya) (Faye 2015). Dromedary camels produce more milk for a longer period of time than any other milk animal held under the same harsh conditions. Camel milk is a valuable food source for humans in the arid and semi-arid environment of eastern Africa (Farah et al. 2007); particularly, it is a primary source of food, nutritional and income security all year round for some pastoralists in the region (Elhadi et al. 2015; Kebede et al. 2015; Wako 2015). Furthermore, camel milk enhances livelihoods and contributes to national and global economic growth and development (Faye et al. 2011). Camel milk is also used as a traditional medicine to treat several diseases, and as a result, it builds the immune system of human beings when consumed occasionally (Kumar et al. 2004; Sharma and Singh 2014; Yadav et al. 2015; Jilo 2016). Therefore, camel milk is at the core of some pastoralists' culture, life and health and is considered as white gold of the desert (Gul et al. 2015).

The pastoral area of Ethiopia is the main camel belt in the horn of Africa. It is known by a camel culture, a monoculture which is expressed as an adaptation to arid ecology through dependence on the camel based on uniform husbandry methods and mobility (Tefera 2012). In Ethiopia, camels are mainly reared in Afar and Somali regions and Borena and Kereyu areas of Oromia region (Tekle and Tesfay 2013). Ethiopia holds a third of the world camel population that is about 2.4 million heads, of which 458,760 were lactating camels (FAO 2011), with an annual milk production of 608,315,760 L that roughly generates USD 196,449,900 (Hussein et al.

* Correspondence: belets.gebremicael@mu.edu.et
[1]Department of Agricultural and Resource Economics, College of Dry Land Agriculture and Natural Resource, Mekelle University, P.O. Box 231, Mekelle, Ethiopia
Full list of author information is available at the end of the article

2011). Utilization of the milk is largely governed by the need of the community and other cultural and traditional limitations, but selling of camel milk was not common in Afar tradition. Most of the Ethiopian pastoralists use milk as a staple food, which indicates the prestigious value of camel in the region. As a result, camels' contribution to immediate and direct household income was low in comparison with other livestock products (Tadesse et al. 2013). Despite the significance of camel milk to livelihoods of the pastoralists in Afar, camel milk potential and its marketing has not been fully explored by government and private sectors as compared to cows' milk. This study, therefore, aimed at investigating the status of camel milk production and marketing, and the corresponding importance, opportunities and challenges in pastoral households of the Afar region.

Study area

Afar Regional State is one of the nine regional states of Ethiopia and lies between latitude 11° 49′ N and longitude 41° 25′ E and covers an estimated area of 270,000 km^2. The altitude of the region ranges from 116 m below to 1600 m above sea level; its temperature varies from 25 to 48 °C and average annual rainfall registered 187.9 mm. It is the homeland of Erta-Ale active volcano and the world's oldest hominid fossils—*Lucy*, *Ardi* and *Selam*. It is also rich in salt, potash, sulphur, manganese, bentonite, aluminium, marble, gypsum and petroleum and is promising in geothermal energy. The Great Rift Valley passes through the southern part of the region which consists of the Awash River valley which drains into a string of lakes along the Ethiopian-Djibouti border. Hence, as depicted in Fig. 1, the study districts lie along this international highway and Awash valley. It has common boundaries with the State of Eritrea in the north-east, Tigray in the north-west, Amhara in the south-west, Oromia in the south, the State of Somalia in the south-east and the Republic of Djibouti in the east (EPRDF Portal 2018).

The region had a population of 1,390,273 according to the last census, comprising 775,117 men and 615,156 women; urban inhabitants are 185,135 of the population and 1,205,138 are pastoralists (CSA 2012). Livestock is the basis of livelihood for the Afar people, with a population of 703,424 cattle, 1,003,000 sheep, 2,014,418 goats and 16,976 donkeys (ANRS 2010). Afar camels account for 320,121. The number of camels measures the person's wealth status; a rich person (*Ele-habo Gadeli*) could have as high as 1000 camels, *Too-degoyeta* (a person who owns 30–50 camels), *Haan-nakayetu* (a person with 2–5 camels) and *Alaa-meli* (a person without a single camel) (APDB 2012).

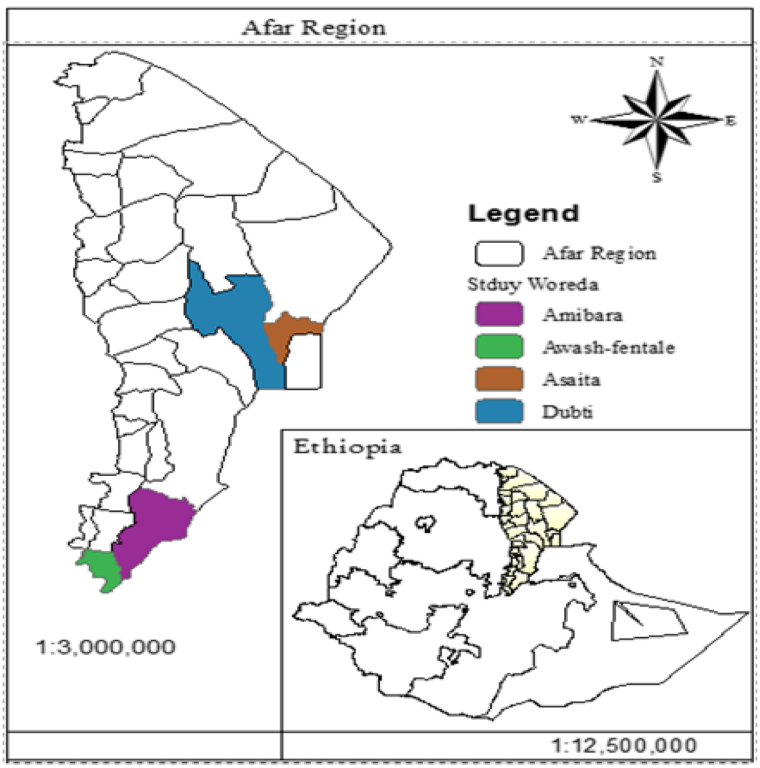

Fig. 1 Location map of study districts

Methods and materials

Study design and data collection method

Three-stage sampling procedure was employed to select camel herding samples. First, four districts, namely, Aysaita, Dubti, Amibara and Awash-Fentale, were selected purposively based on their access to the market and accessibility to roads and towns. Second, the same procedure was followed to select a single pastoral village from each district. Third, camel herding households having lactating camels were selected conveniently from these villages. The sample size was determined based on Arsham (2007) formula at 5% standard error since the camel herders have a homogenous production system and social values. Middlemen were selected using snowball sampling technique.

A semi-structured questionnaire was developed to collect quantitative and qualitative data through the interview schedule. Quantitative data were collected such as: camel herd composition, camel milk yield, production, marketing, price and sales, and qualitative data such as milking practice, milk handling, camel milk importance, challenges and opportunities perceived by respondents. Focus group discussions and key informants interviews were also made using checklists. Therefore, a cross-sectional survey was conducted among 100 camel herding households; nine traders and three cooperatives between March and April 2017.

In each village, a single focused group discussion was conducted as well as interviews made with camel herding, district leaders, end consumers and local elders to give more insights on camel milk production, consumption and marketing. Furthermore, reviews were made of a camel roadmap report, proceedings, the camel forum of Ethiopia reports, development partners' reports, published journals and other sources of secondary data.

Data analysis

Collected data was analysed by descriptive statistical tools using SPSS version 20. Camel herd composition, milking practice, milk handing, transaction, challenges and opportunities were presented using frequency, percentage and figures. Besides, milk yield, production, price and sales were presented using mean and standard deviation. Camel milk channels and amount of milk flow along each channel were presented in a diagram.

Results and discussion

Camel herd composition of herding households

About 87.5% of the herds were female camels. The mean household camel herd composition comprised lactating camels 17.32(56.6%), followed by dry camels 9.49(30.9%) and male camels 3.82(12.4%) (Fig. 2). In comparison, in Kereyu, 90% of camel heads are female camels, in which 30% were lactating camels (Temesgen et al. 2011); in Sudan, lactating camels are 25% and males are 9%, of which 7% were slaughtered (Faye et al. 2011, while 70% camels in Kenya are lactating, which shows households were keeping camels for milk production (Elhadi et al. 2015). This implies that female camels far exceed male camels to ensure reproductive potential and good milk production for pastoralists as food. Tadesse et al. (2014) also found that in Afar and Somali pastoral societies, wealth is assessed mainly on the basis of the number of female camels owned to ensure food availability and to facilitate herd recovery from mortality due to recurrent droughts in the area.

Camel milking practice and milk yield

During the survey, it was observed that milking was done after the calf suckled the dam for a few minutes to stimulate milk let down. Milking was done by two men. One man conducts the milking with one knee raised to

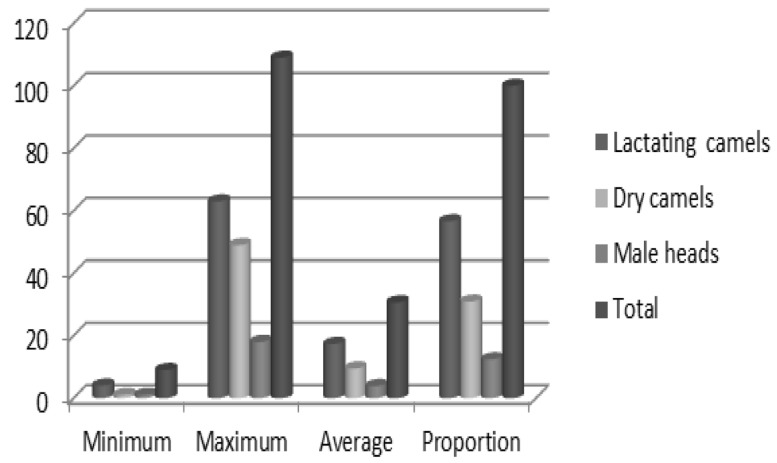

Fig. 2 Camel herd composition of households

support the milking vessel while the other holds the calf to prevent it from suckling and to assist the man milking (Fig. 3, middle). Kebede et al. (2015), Seifu (2009) and Simenew et al. (2013) argue that in Afar and Somali pastoralists, women are not allowed to milk camels due to the communities' belief that lactating camel do not let down sufficient milk for women. This is similar in Kenya, Somalia and in most parts of Sudan except among the Rashaida tribe where camel milking is practised by women (Eisa and Mustafa 2011). In Afar, milking was done using smoked milking vessel—locally called *Ayni* (Fig. 3, left) made from grass. Smoking the milking vessel with local herbs is believed to improve the flavour, taste and quality, as well as extend the shelf life of the milk. This is in line with reports of Seifu (2007) and Wanjala et al. (2016) that smoking of milk handling containers was effective in hindering microbial growth and could be used as a technique in the sanitation and preservation of raw camel milk in arid and semi-arid areas where cold chains for preservation of milk were unavailable.

The findings showed that the majority (67%) of the camel herders milked their camels twice a day whereas 33% of the households milked three times a day (Table 1). The milking was conducted in the mornings and evenings and rarely in the afternoon at grazing area. A similar milking frequency was reported by Simenew et al. (2013). The Afar people believed three milkings per day give a better yield than two milkings (Nega and Tefera 2012). Contrasting results were however reported in the Somalia region, where milking frequency ranged from one to five times a day (Kebede et al. 2015). Thus, the number of milkings per day may vary depending on the pastoral society, season and feed availability that could have an effect on milk production.

The estimated average daily milk yield per camel under pastoralists' milking practices ranged from 2 to 6 L (4.2) (Table 1). The milk yield was measured using small (1 and 2 L) plastic pots and 5-L plastic jerrycans, and all lactating camels were not milked out all the time. Earlier studies conducted in Afar by Nega and Tefera (2012) and Simenew et al. (2013) had reported the daily milk with a range of 0.5–8 and 3–7.62 L, respectively. However, it was difficult to estimate the exact daily yield of the camels under pastoralist conditions, because milk variability is subject to milking practices, breed, season, feeding, stage of lactation, calf survival and household milk demand.

Camel milk utilization

The proportion of household camel milk utilization depends on the accessibility of pastoralists to the market, the numbers of milking animals, seasonal fluctuation with climate, the quantity of milk produced and the number of neighbours and relatives that have insufficient numbers of milking animals. In Ethiopia, camel milk is consumed by Muslims only and by none of the Christians; hence, it is highly utilized by the Muslim pastoral communities of Afar and Somali (Tefera et al. 2012). Given these conditions, camel milk is considered the main nutritional source for Afar people, consumed in its raw form under the belief that when boiled the camel will die. Camel herders also indicated that children are the primary consumers as they believed that camel milk can substitute for mother's milk; thereby people considered camel milk as a means for survival (Fig. 4).

Children drinking camel milk have had amazing improvements in their behaviour and diets (Abbas et al. 2013). The lactose content of camel milk (4.8%) is almost similar to human mother's milk and thus can be readily digested by individuals suffering from lactose

Fig. 3 Camel milking practice

Table 1 Milking frequency and milk yield of she-camels

Description		*N* = 100	
		Frequency	Percentage
Milking frequency per day	Twice	67	67
	Three times	33	33
	Minimum	Maximum	Mean (STD)
Milk yield (litres per day per she-camel)	2	6	4.2 (1.46)

N number of camel herder, *STD* standard deviation of the mean
Source: Survey Data, 2017

intolerance (Lvy et al. 2011). Moreover, camel milk is also consumed along with goat and cow milk in lowland pastoral or agro-pastoral areas of Ethiopia while consumption of camel milk in the mainly Christian highland areas was limited due to a traditional taboo (Tegegne et al. 2013). In Sudan, camel's milk constitutes the sole diet of camel herders for considerable periods and they rely completely on camel's milk for more than a month without having drinking water, especially along the migratory routes (Eisa and Mustafa 2011). More recently, camel milk was marketed in urban areas of Sudan and consumed as fresh, fermented and boiled milk (Faye et al. 2011). But the preparation of butter and cheese from camel milk was not a tradition in most pastoral societies in eastern Africa (Farah et al. 2007).

Camel milk marketing and sales value

Sale of milk has been considered a taboo in Afar and Somali communities. However, selling is on the rise partly due to the settlement of pastoralists and consumer demand for camel milk, as well as a break in traditional beliefs (Tefera et al. 2012). As reported by Simenew et al. (2013), some evidence was seen in the main roads of Afar. In our survey, 82% camel households had participated in selling their surplus camel milk, while the rest were reluctant to sell their milk due to traditional taboos. Selling camel milk is also a source of income, and there are a number of camel milk collection centres selling milk in local towns and cities of the Somali region of Ethiopia, as well as exported to the neighbouring country of Somaliland (Mehari et al. 2009; Hussein et al. 2011). Similarly, in Meiso (Oromia) lowlands of Ethiopia, the majority of pastoralists (78%) had been selling camel milk, but it was not culturally accepted to sell fermented milk (Tegegne et al. 2013). Milk selling is the role of women in Afar, and this is similar in the Somali region of Ethiopia where it was traditionally and dominantly marketed by women and their organizations along kinship lines (Seifu 2007; Lumadede et al. 2010).

Camel herders sold between 4 and 30 L per day at a price range of USD 0.83 to 1.16, while middlemen had sold between 20 and 100 L per day at a price range of USD 1.16 to 1.39. The estimated camel milk sales value ranged between USD 3.71 and 34.80 at household level as well as between USD 23.20 and 139.20 at middlemen level (Table 2). These figures confirmed that herders' movements for their livestock's feed and water by season, in addition to their market orientation are the main reasons for high variability (± 8.17) of milk supply; as a result, income generation became less effective.

During the survey, raw camel milk was sold at camel herders' farm gate (18.3%), main road-sides (58.5%) and nearest towns (23.2%) (Fig. 5, right). The milk handling containers used for buying and selling was 1- or 2-L plastic pots (68.3%) and 3- or 5-L plastic jerrycans (31.7%) (Fig. 5, left) This implies that camel milk was

Fig. 4 Camel milk as pastoralists' children food in afar

Table 2 Camel milk marketed and its sales value (in USD)

Variables	$N_h = 82$, $N_m = 12$		
	Minimum	Maximum	Mean (STD)
Amount of milk sold by herder per day	4	30	14.3 (8.17)
Camel milk selling price by herder	0.83	1.16	0.95 (0.12)
Amount of milk sold by middlemen per day	20	100	35.8 (28.32)
Camel milk selling price by middlemen	1.16	1.39	1.22 (0.10)
Camel herder income generated per day	3.71	34.80	13.97 (8.81)
Camel middlemen income generated per day	23.20	139.20	43.85 (31.77)

N_h number of camel milk seller respondents, N_m number of camel milk middlemen, *STD* standard deviation of the mean; 1 ETB = 0.0464 USD at study period
Source: Survey Data, 2017

marketed in an unorganized manner using unprotected containers; as a result, there was a high probability of milk contamination and spoilage. In Somali region of Ethiopia, milk was usually delivered in plastic jerry-cans (57%) and gourds (43%) A study by Lumadede et al. (2010). Noor et al. (2013) also argue that ordinary plastic jerrycans are difficult to clean and thus contribute to the frequent milk spoilage.

Camel milk marketing actors and channels

Camel milk actors included individuals and groups who have participated from production up to consumption. Thus, in this case, camel milk core actors were found to be camel herders, traders, formal and informal cooperatives and end consumers.

Camel herders included those who had lactating camels, and they mostly obtain higher prices compared to middlemen - (USD 1.16/L) when selling directly to end consumers in contrast to middlemen (USD 0.83/L) (Fig. 6, left). The formal milk marketing cooperatives were organized under legal procedures (Fig. 6, middle), while the informal milk marketing cooperatives were simply organized into groups comprising of close family or nearby herders who collectively sell their milk at the nearest town. Involving women in these groups gave them a higher bargaining power over groups where women were absent. The purpose of informal cooperatives was to minimize transport costs. Such clan-based organizations of women in milk marketing were common in pastoral areas of Oromia (Tegegne et al. 2013) and Somali regions (Lumadede et al. 2010) in Ethiopia.

The traders were equipped with some cooling facilities, mainly the refrigerator at their shop. The traders were either collecting milk themselves from pastoralists'

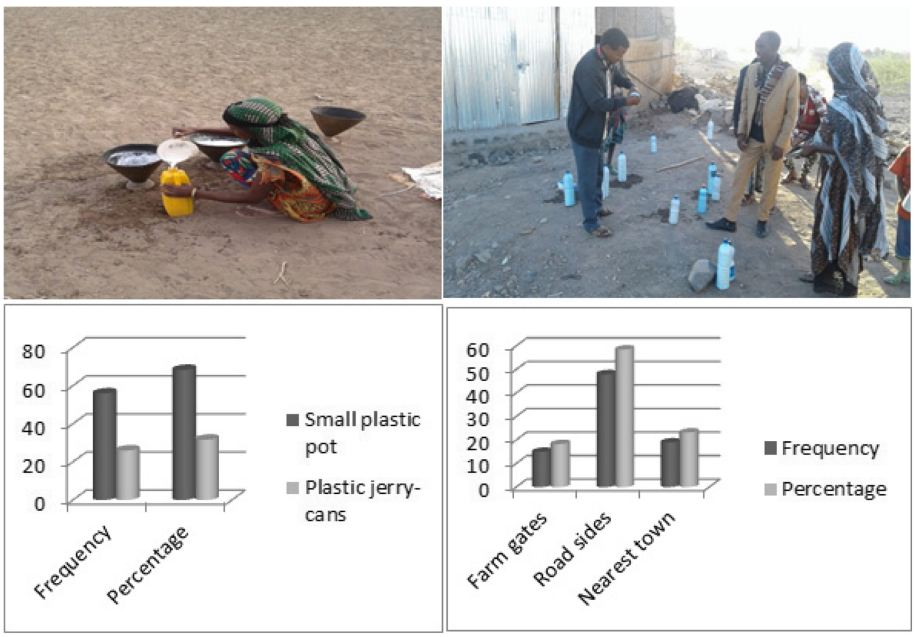

Fig. 5 Milk handling (left) and marketing (right)

Fig. 6 Camel milk marketing at farm gate (left), cooperative (middle) and trader shop (right)

farm gates (at USD 0.83/L) or buying from camel herders who brought the milk to their shops (at a mean price of USD 1.16/L); as a result, the traders sold the milk at prices from USD 1.16 to 1.39 per litre to end consumers. Hence, they could be considered both as collectors and retailers (Fig. 6, right). Consumers are individuals who consume camel milk both as food and medicine. All of the consumers preferred the milk in its fresh state, and it is highly required at the time of Muslims' fasting period in Ramadan. End consumers' price varied from USD 1.16/L bought from camel herders to 1.39/L from middlemen. Therefore, the milk is highly consumed in the Afar pastoral areas by both camel herder households and other Islamic followers, but it was not easily available at restaurants and cafés for buyers.

Figure 7 shows that 69.9% of the milk was sold to end consumers in its raw form and camel herders obtain higher prices than any other alternative channel. Others channels were cooperatives and traders which directly pass the milk to end consumers without adding any value to it. Although there was a private milk processing factory in Awash town which aimed to process camel milk in line with cow milk for exporting to neighbouring countries (Djibouti), the milk marketing routes were limited to the locality. Pastoralists of Somali region in Ethiopia had varied market routes such as to Dire-dawa and Harar towns, and neighbouring Somaliland (Hargeysa) and Somalia (Mogadishu) (Kebede et al. 2015). This indicates that in Ethiopia, camel milk has domestic and international possible marketing routes, which needs attention as the commodity is a source of foreign earnings.

Pastoralists' beliefs on camel milk usefulness

During the survey, all pastoralists considered camel milk as ready on-hand medicine for different diseases. Dromedary camel milk has been believed to provide potential treatment for diseases such as jaundice, malaria, constipation, stomach ulcers, postpartum of women, snake bite and flatulence (Seifu 2007) and diabetics in Somali region (Bussa et al. 2017); jaundice, malaria and constipation in Kenya (Akweya et al. 2012); diarrhea, constipation, stomach ulcers, wounds and liver disorder in Pakistan (Abbas et al. 2013); diarrhea and autism in Israel (Yagil 2013); tuberculosis and HIV/AIDS related problems in hospitals of Arab countries (Nori et al. 2018); gastroenteritis, tuberculosis, diabetics, allergies, autism, liver inflammation, arthritis and cancer in India (Kumar et al. 2004). This may be due to the fact that camels browse on various plant species and active agents with therapeutic properties secreted into the milk (Seifu 2007; Bussa et al. 2017). In this regard, most of the interviewed pastoralists indicated that camel milk is

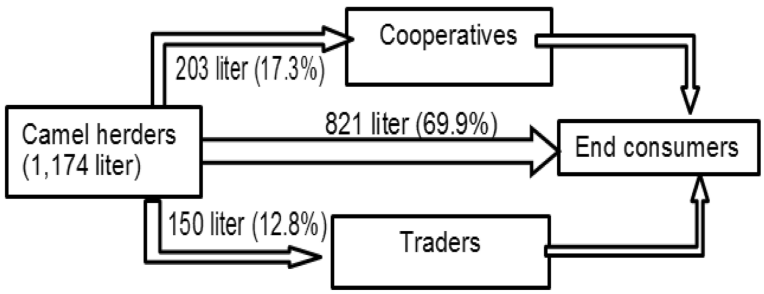

Fig. 7 Camel milk market channels

Table 3 List of diseases claimed to be treated by camel milk

English Name	Amharic Name	*Afar af* (local) Name	% of respondents
Liver disease	የጉበት በሽታ	Tirobiyaaka	91
Abdominal diseases	የሆድበ ሽታ	Bagibiyaaka	89
Anemia	የደም ማነስ	Qabalibiyaaka	67
Malaria	ወባ	Qaso	73
Swelling	እብጠት	Dudduba	62
Joint pain	የመገጣጠምያ ህመም	Dagarbiyaaka	75
Jaundice	የወፍ በሽታ	Kimbiro (qdiro) biyaaka	100
Allergy	አለርጂክ	Wayibo	91
Tuberculosis (TB)	ቲቢ	Kacuw (tiibi)	76
Constipation	የሆድ ድርቀት	Bagikafna	90
Asthma/Asthmatics	አስም	Asim	84
Urine obstruction	የሽንት መዝጋት	Daacomabuuxu	69
Diabetics	የስኪር በሽታ	Sokkarbiyaaka	92
Gastritis	የጨጓራ በሽታ	Alilliiqi	88
Spleen disease	የጣፍያ በሽታ	Qasoxaa	89
Snake bite	የእባብ ንክሻ	Baaxohalihbiyaaka	74
Food poisoning	የምግብ መመረዝ	Hora	87
Kidney infections	የኩላሊት በሽታ	Akiyabare	71
HIV/AIDS	ኤድስ	Siida	57
Diarrhea	ተቅማጥ	Urruuga / Bag-gero	100

Source: Survey Data, 2017

extensively applied to treat a wide range of diseases as presented in Table 3.

Moreover, as indicated in Table 4, all pastoralists perceived that camel milk is a nutritionally rich food because it gives strength and endurance mainly for aged people and children. It is also consumed as an item of ensuring food security by all camel herders. Amante (2014) also found that people who suffer from malnutrition are typically sent to camel herders to drink milk and recover, and children who drink camel milk grow faster and stronger. They also believed that camel milk strengthens social linkages amongst pastoral communities. It bridges marriage linkage and compensation of injured parties in clan disputes and is a social offering for a guest. Nori et al. (2018) found that the milk is used as a gift, as part of a system of maintaining family ties and mechanisms of social support in the arid areas of eastern Africa. In addition, camel milk is considered as an additional source of income and creates job opportunities in households. This finding also supported by Seifu (2007), Noor et al. (2013), Elhadi et al. (2015), Kebede et al. (2015) and Wako (2015) who have found that camel

Table 4 Camel milk importance perceived by the camel herders

Perceived indicator	% of respondents
Medicinal purpose	100
Food purpose	100
Social linkage	100
Economic value	82

Source: Survey Data, 2017

milk had been contributing significantly to pastoralists' income and daily food throughout the year.

Challenges and opportunities towards camel milk production and marketing

Challenges

It was observed that only a small volume of milk was marketed by the camel herders, and middlemen were not fully involved in the milk trading due to the factors discussed below (Fig. 8). The major sources of camel feed in Afar region are natural pasture and browse species, but rangeland-based animal feed resources are declining year after year due to cutting trees for making charcoal and firewood, as well as due to recurrent drought. Thus, feed availability is a very critical challenge contributing to low milk productivity. Camel diseases were another concern in the Somali region of Ethiopia, leading to low milk productivity (Kebede et al. 2015). There was no transport service which fulfils the need of camel herders to carry their milk long distances to markets; hence, camel herders are forced to sell their produce at the farm gate. Underdeveloped marketing infrastructure had forced the women in the Somali region to sell their milk at the roadsides. Poor infrastructure also led to the absence of conventional milk value addition as compared to the Kenyan pastoral systems (Noor et al. 2013).

Limited efforts have been initiated by Ethiopian Meat and Milk Institute (EMMI) and the Pastoral Resilience Improvement through Market Expansion (PRIME) project in providing technical training and financial support to build pastoralists' milk handling, marketing capacity and capability. However, it was revealed in our study of Afar region that there were scant support services provided to camel herders and middlemen in terms of camel health, milk safety and improved technical facilities. Camel herders and informal cooperatives were observed selling their milk on roadsides using plastic containers which have a high probability of being contaminated and spoiling the milk. Similarly, in the Somali region, poor milk storage and processing facilities led to the loss of milk (Kebede et al. 2015). Muslims are the main consumers of camel milk, but some do not drink for fear of diarrhoea. However, Christian people in Ethiopia are forbidden to consume camel milk. On the other hand, some camel herders are still reluctant to sell camel milk due to the traditional belief that *if they sell camel milk their camel milk production will decrease and eventually die*. They had not allowed milk to be sold for fear of boiling the milk and thereby decreasing its nutritional and medicinal value.

Opportunity

Even though camel milk production and marketing fall under different challenges, there are various opportunities which would allow the commodity to move forward as a business (Fig. 9). The large number of female camels kept by each household would be a main source for surplus milk production throughout the year. Tadesse et al. (2013) confirmed that a large number of a camel population dominated by females is indicative of the importance of camels as milk providers to the pastoral community, in addition to the adaptability of the animal to the hostile environment of the area. Besides, camel herders in our survey confirmed that consumption of camel milk has better nutritional and medicinal value and longer shelf life compared to other livestock milk. Shelf life is recorded as 7seven days (Seifu 2007). It has been also observed that the price of camel milk was increasing from year to year and the market price was remarkable (USD 1.16–1.39 per litre) relative to other livestock milk price, e.g. cow milk (mean USD 0.55/L). As a result, consumers purchase the milk without compromising about its price. Tefera et al. (2012) also

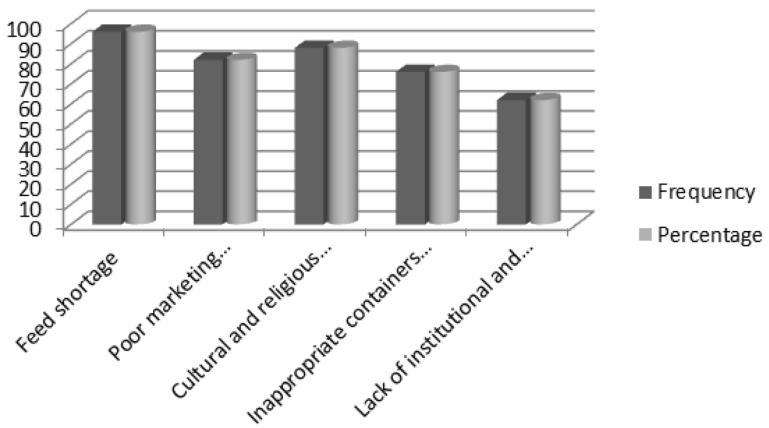

Fig. 8 Challenges of camel milk production and marketing

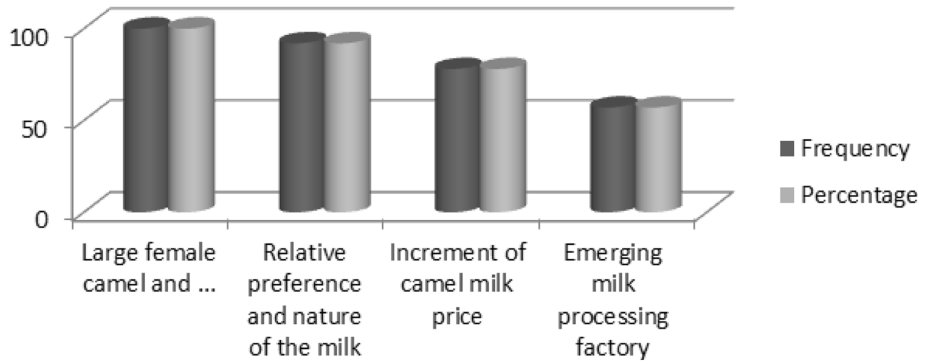

Fig. 9 Opportunities of camel milk production and marketing

confirmed that camel milk fetches the highest price in Afar and Somali regions and has the highest turnover irrespective of the season. This implies that camel milk was highly valued despite its cost. During the survey period, a milk processing factory was being installed in the region, which aimed to collect raw milk from a distance of 100 km radius, which would be good fortune for camel milk to break through into the value chain.

Conclusions and recommendations

Raw camel milk is considered as the key to pastoralists' children's survival amongst the Afar. Camel milk is rich in nutritives, creates cash income, builds social relations and is used to treat a wide range of diseases. There are opportunities for the commodity move forward as a business; however, it is constrained by feed shortage for camels, poor marketing services, unavailability of clean milk containers and milk collection centres, traditional taboos and lack of institutional and technical support. Therefore, the following recommendations are put forward to better realize the camel milk production and marketing efficiency and effectiveness.

- Provision of continuous training of the pastoralists would change the traditional taboos related to selling of camel milk, thereby enhancing household income generation.
- The regional government needs to call on private investors to engage in camel milk value addition.
- Interventions on camel milk should target women and recognize the informal cooperatives, allowing them to enter into formally organized camel milk business.
- Camel herders and middlemen need to use appropriate milk containers made up of aluminium and hygienically prepared during collection, transportation and storage of the milk, to ensure safety and quality standards of the milk.
- Regulations on forest protection against illegal cutting of trees for making charcoal and firewood, and conservation of natural resource would minimize the camel feed shortage, thereby improving camel milk productivity.
- The real medicinal importance of camel milk for the treatment of diseases mentioned by the camel herders should be further investigated scientifically.

Acknowledgements
We, primarily, would like to convey our heartfelt gratitude to the Ethiopian Institute of Agricultural Research (EIAR) for the research grant. Our thanks also extended to Samara University for the facilitation of the grant and assistance for field logistics. Without these two institutions, our research work could not be realized. We also wish to thank all enumerators, camel herders and middlemen for their willingness to participate in the study.

Authors' contributions
BG participated in the design of the study, carried out the statistical analysis and drafted the manuscript. SG designed the study, coordinated the data collection and participated in drafting the manuscript. MG participated in the design of the study, participated in data collection, analysis and interpretation of the result and helped to draft the manuscript. All authors read and approved the final manuscript.

Funding
This study was supported by the funds from Ethiopian Institute of Agricultural Research (EIAR), Ethiopia. The funding institution was not involved in the collection, analysis and interpretation of the data and in writing the manuscript.

Availability of data and materials
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate
Not applicable

Consent for publication
Not applicable

Competing interests
The authors declare that they have no competing interests.

Author details
[1]Department of Agricultural and Resource Economics, College of Dry Land Agriculture and Natural Resource, Mekelle University, P.O. Box 231, Mekelle, Ethiopia. [2]Department of Animal Science, College of Dry Land Agriculture,

Samara University, P.O. Box 132, Samara, Ethiopia. [3]College of Veterinary Medicine, Mekelle University, P.O. Box 231, Mekelle, Ethiopia.

Received: 12 January 2019 Accepted: 7 June 2019
Published online: 29 October 2019

References

Abbas, S., H. Ashraf, A. Nazir, and L. Sarfraz. 2013. Physico-chemical analysis and composition of camel milk. *International Researchers* 2 (2): 82–98.

Akweya, B.A., C.G. Gitao, and M.W. Okoth. 2012. The acceptability of camel milk and milk products from north eastern province in some urban areas of Kenya. *African Journal of Food Science* 6 (19): 465–473. https://doi.org/10.5897/AJFS10.061.

Amante, D.G. 2014. *Traditional camel management as an adaptation strategy to ecological changes: The case of Karrayyuu Oromo of Ethiopia*.

ANRS. 2010. Assessment of afar national regional state for climate change adaptation. http://www.epa.gov.et/Download/Climate/Regional.

APDB. 2012. Camel development road map: Afar agriculture and pastoral development bureau (APDB).

Arsham, H. 2007. *Perturbed Matrix Inversion with Application to Linear Programs Simplex Method: Applied mathematics and computation*, 188.

Bussa, N., A. Belayneh, and M. Dheresa. 2017. The potential of camel milk and extracts of major plants browsed by the animal for diabetes treatment. *East African Journal of Sciences* 11 (2): 129–138.

CSA. 2012. Population and housing census of Ethiopia: Administrative report by central statistical authority (CSA).

Eisa, M.O., and A.B. Mustafa. 2011. Production systems and dairy production of Sudan camel (Camelus Dromedarius): A review. *Middle-East Journal of Scientific Research* 7 (2): 132–135. https://doi.org/10.1002/qua.20166.

Elhadi, Y.A., D.M. Nyariki, and O.V. Wasonga. 2015. Role of camel milk in pastoral livelihoods in Kenya: Contribution to household diet and income. *Pastoralism* 5 (1). https://doi.org/10.1186/s13570-015-0028-7.

EPRDF Portal. 2018. Ethiopian People Republic democratic federation (EPRDF) government portal. Ethiopian Government Portal. 2018. http://www.ethiopia.gov.et/afar-regional-state?. Accessed 07 Dec 2018.

FAO. 2011. *World livestock: Livestock in food security*. Rome. https://doi.org/10.1080/00036841003742587.

Farah, Zakaria, Matthias Mollet, Mario Younan, and Ragge Dahir. 2007. Camel dairy in Somalia: Limiting factors and development potential. *Livestock Science* 110 (1–2): 187–191. https://doi.org/10.1016/j.livsci.2006.12.010.

Faye, B. 2015. Role , distribution and perspective of camel breeding in the third millennium economies. *Emirates Journal of Food and Agriculture* 27: 1989–1993. https://doi.org/10.9755/ejfa.v27i4.19906.

Faye, B., O.M.A. Abdelhadi, A.I. Ahmed, and S.A. Bakheit. 2011. Camel in Sudan: Future Prospects. *Livestock Research for Rural Development* 23 (10). http://www.lrrd.org/lrrd23/10/faye23219.htm

Gul, W., N. Farooq, D. Anees, U. Khan, and F. Rehan. 2015. Camel milk: A boon to mankind. *International Journal of Research Studies in Biosciences* 3 (11): 23–29.

Hussein, A.A., S.M. Ali, and A.E. Tahir. 2011. Pastoral innovation in Somali region-town camels and milk villages the case of Gode town. In *Ninth international conference on the Ethiopian economy July 2011*. Addis Ababa: Ethiopian Economic Association.

Jilo, K. 2016. Medicinal values of camel Milk. *International Journal of Veterinary Science and Research* 2 (1): 18–25. https://doi.org/10.1111/pce.12367.

Kebede, S., G. Animut, L. Zemedu. 2015. The contribution of camel milk to pastoralist livelihoods in Ethiopia an economic assessment in Somali Regional State. Drylands and Pastoralism. https://pubs.iied.org/pdfs/10122IIED.pdf.

Kumar, R.P., G.C. Ram, V.K. Narendra, and S. Ranga. 2004. *Camel Milk: Natural Medicine - Boon to Dairy Industry*. Karnal: ICAR-National Dairy Research Institute.

Lumadede, A.K., G. Owuor, H. Laqua, and I.V. Gluecks. 2010. *Pastoral milk production and market chain analysis in Dollo ado and Dollo Bay, Somali region of Ethiopia for save the children/US – version*.

Lvy, A., C.V. Creveld, and R. Yagil. 2011. Curing diseases associated with immune disorders. In *Proceedings of International Conference on Camel Research and Development*. Jigjiga: Ethipian Institute of Agricultural Research (EIAR).

Mehari, Y., Z. Mekuria, and G. Gebru. 2009. Potentials of camel production in Babilie and Kebribeyah wore- das of the Jijiga zone, Somali region, Ethiopia. In *Proceedings of the 17th Annual Conference of the Ethiopian Society of Animal Production (ESAP) Held in Addis Ababa, Ethiopia, September 24 to 26, 2009*.

Nega, Solomon, and Melaku Tefera. 2012. Production and productivity of the camel. In *Camel in Ethiopia*, ed. Melaku Tefera and Getachew Abebe, 76–92. Addis Ababa: Ethiopian Veterinary Association.

Noor, I.M., A.Y. Guliye, M. Tariq, and B.O. Bebe. 2013. Assessment of camel and camel milk marketing practices in an emerging peri-urban production system in Isiolo County, Kenya. *Pastoralism* 3: 28. https://doi.org/10.1186/2041-7136-3-28.

Nori, M., M.B. Kenyanjui, M.A. Yusuf, and F.H. Mohammed. 2018. Milking drylands: The marketing of camel milk in north-east Somalia. *White Horse Press* 10 (1): 9–28 https://www.jstor.org/stable/43124131.

Seifu, E. 2007. Handling, preservation and utilization of camel milk and camel milk products in Shinile and Jijiga zones, eastern Ethiopia. *Livestock Research for Rural Development* 19 (86) https://lrrd.cipav.org.co/lrrd19/6/seif19086.htm.

Seifu, E. 2009. Analysis on the contributions of and constraints to camel production in Shinile and Jijiga zones, eastern Ethiopia. Journal of Agriculture and Environment for International Development 103 (3): 213–224.

Sharma, C., and C. Singh. 2014. Therapeutic value of camel milk. *Advanced Journal of Pharmacie and Life Science Research* 2 (3): 7–13.

Simenew, K., T. Dejen, S. Tesfaye, R. Fekadu, K. Tesfu, and D. Fufa. 2013. Characterization of camel production system in Afar pastoralists, North East Ethiopia. *Asian Journal of Agricultural Sciences* 5 (2): 16–24.

Tadesse, Y., M. Urge, S. Abegaz, M.Y. Kurtu, and K. Kebede. 2013. Camel and cattle population dynamics and livelihood diversification as a response to climate change in pastoral areas of Ethiopia. *Livestock Research for Rural Development* 25 (9). https://www.lrrd.cipav.org.co/lrrd25/9/yose25166.htm

Tadesse, Y., M. Urge, S. Abegaz, M.Y. Kurtu, K. Kebede, and T. Dessie. 2014. Husbandry and breeding practices of dromedary camels among pastoral communities of Afar and Somali regional states, Ethiopia. *Journal of Agriculture and Environment for International Development*. https://doi.org/10.12895/jaeid.20142.238.

Tefera, M. 2012. Camel in Ethiopia. In Ethiopian Veterinary Association, Melaku Tefera, Getachew Abebe, 9–39. Addis Ababa: Ethiopian Veterinary Association

Tefera, M., B. Admassu, and F. Abnet. 2012. Camel marketing and its value chain in Ethiopia. In *Camel in Ethiopia*, ed. Melaku Tefera and Getachew Abebe, 93–117. Addis Ababa: Ethiopian Veterinary Association.

Tegegne, A., B. Gebremedhin, D. Hoekstra, B. Belay, Y. Mekasha. 2013. Smallholder dairy production and marketing systems in Ethiopia: IPMS experiences and opportunities for market-oriented development. www.ipms-ethiopia.org www.eap.gov.et.

Tekle, T., and Y. Tesfay. 2013. Production potential of camels (Camelus Dromedarius) under pastoral and agro-pastoral systems in North Afar, Ethiopia. *Livestock Research for Rural Development* 25 (12): 13.

Temesgen, D., G.W. Wendwessen, and G.T. Tezera. 2011. Assessment of the supply and demand of the camel milk: The case of pastoral community of Kereyu. In *Proceedings of International Conference on Camel Research and development*. Jigjiga: Ethipian Institute of Agricultural Research (EIAR).

Wako, G. 2015. *Economic value of camel milk in pastoralist communities in findings from Yabello District, Borana Zone*. https://doi.org/10.1111/j.1365-2982.2011.01828.x.

Wanjala, N.W., J.W. Matofari, and J.M. Nduko. 2016. Antimicrobial effect of smoking milk handling containers' inner surfaces as a preservation method in pastoral systems in Kenya. *Pastoralism* 6 (17). https://doi.org/10.1186/s13570-016-0064-y.

Yadav, A.K., R. Kumar, L. Priyadarshini, and J. Singh. 2015. Composition and medicinal properties of camel milk: A review. *Asian Journal of Dairy and Food Research* 34 (2): 83–91. https://doi.org/10.5958/0976-0563.2015.00018.4.

Yagil, R. 2013. Camel milk and its unique anti-diarrheal properties. *Israel Medical Association Journal* 15: 35–36.

Publisher's Note